## CLAIMS

What is claimed is:

1. A triple-junction solar cell comprising:

a first cell layer comprising a germanium (Ge) substrate doped with an n-type dopant;

a nucleation layer disposed over the first cell layer;

a second cell layer comprising gallium arsenide (GaAs) disposed over the nucleation layer; and

a third cell layer comprising indium gallium phosphide (InGaP) disposed over the second cell layer.

2. The triple-junction solar cell as recited in Claim 1 wherein the nucleation layer comprises a material having a lattice parameter substantially equal to the lattice parameter of the germanium substrate.

3. The triple-junction solar cell as recited in Claim 1 wherein the nucleation layer comprises InGaP.

4. The triple-junction solar cell as recited in Claim 1 wherein the nucleation layer has a thickness substantially equal to 350 Å or less.

5. The triple-junction solar cell as recited in Claim 1 capable of absorbing radiation ranging from approximately ultraviolet (UV) radiation to radiation having a wavelength of approximately 1800 nm.

6. The triple-junction solar cell as recited in Claim 1 wherein the n-type dopant in the germanium substrate comprises phosphorus (P).

7. The triple-junction solar cell as recited in Claim 1 wherein the n-type dopant in the germanium substrate comprises arsenic (As).

8. The triple-junction solar cell as recited in Claim 1 wherein the junction depth in the first cell layer is substantially between 0.3 μm and 0.7 μm.

9. The triple-junction solar cell as recited in Claim 1 wherein the first cell layer comprises a two-step diffusion profile capable of optimizing current and voltage generated therefrom.

10. The triple-junction solar cell as recited in Claim 1 having 1 sun AM0 efficiencies in excess of 26%.

11. A triple-junction solar cell comprising:

a dual-junction structure comprising a first junction and a second junction;

a third junction having a p-type substrate; and

a nucleation layer disposed between the dual-junction structure and the third junction and comprising a material that shares a substantially similar lattice parameter with the p-type substrate of the third junction, wherein the nucleation layer serves to control the diffusion depth of the third junction.

12. The triple-junction solar cell as recited in Claim 11 wherein the p-type substrate of the third junction is germanium (Ge) and the nucleation layer comprises indium gallium arsenide (InGaP).

13. The triple-junction solar cell as recited in Claim 11 wherein the nucleation layer has a thickness substantially equal to 350 Å or less.

14. The triple-junction solar cell as recited in Claim 11 wherein the third junction is doped with phosphorus (P).

15. The triple-junction solar cell as recited in Claim 11 wherein the third junction is doped with arsenic (As).

16. The triple-junction solar cell as recited in Claim 11 wherein the junction depth of the third junction is substantially between 0.3 μm and 0.7 μm.

17. The triple-junction solar cell as recited in Claim 11 wherein the third junction comprises a two-step diffusion profile capable of optimizing current and voltage generated from the third junction.

18. The triple-junction solar cell as recited in Claim 11 having 1 sun AM0 efficiencies in excess of 26%.

19. The triple-junction solar cell as recited in Claim 11 capable of absorbing radiation ranging from approximately ultraviolet (UV) radiation to radiation having a wavelength of approximately 1800 nm.

20. A method for controlling the diffusion of a dopant into a substrate during a subsequent device process during the fabrication of a multi-layer semiconductor structure, the method comprising the steps of:

(a) disposing a nucleation layer over the substrate; and

(b) performing the subsequent device process to form an overlying device layer containing the dopant, wherein the nucleation layer serves as a diffusion barrier to the dopant in the overlying device layer such that diffusion of the dopant into the substrate can be limited by increasing the thickness of the nucleation layer.

21. The method as recited in Claim 20 wherein the nucleation layer comprises a material that shares an identical lattice parameter with the substrate.

22. The method as recited in Claim 20 wherein the substrate is germanium (Ge) and the nucleation layer comprises InGaP.

23. The method as recited in Claim 20 wherein the nucleation layer has a thickness substantially equal to 350 Å or less.

24. The method as recited in Claim 20 wherein the dopant comprises phosphorus (P).

25. The method as recited in Claim 20 wherein the dopant comprises arsenic (As).

26. The method as recited in Claim 19 wherein a two-step diffusion profile can be achieved in an n-p junction formed in the substrate.

27. The method as recited in Claim 20 wherein the subsequent device process includes metal organic chemical vapor deposition (MOCVD).

28. The method as recited in Claim 20 wherein the nucleation layer also serves as a source of the dopant for forming an n-p junction in the substrate.

29. The method as recited in Claim 20 wherein diffusion of the dopant into the substrate primarily involves solid state diffusion.

30. The method as recited in Claim 29 wherein diffusion of the dopant into the substrate also involves gas phase diffusion during oxide desorption.

31. A method for fabricating a multi-layer semiconductor structure, the method comprising the steps of:

(a) preparing a germanium (Ge) substrate layer for doping by a dopant;

(b) disposing a nucleation layer over the germanium substrate layer;

(c) disposing a middle layer comprising gallium arsenide (GaAs) over the nucleation layer; and

(d) disposing a top layer comprising indium gallium phosphide (InGaP) over the middle layer, wherein the nucleation layer serves as a diffusion barrier such that diffusion of the dopant into the germanium substrate can be limited by increasing the thickness of the nucleation layer.

32. The method as recited in Claim 31 wherein the nucleation layer comprises a material having a lattice parameter substantially equal to the lattice parameter of the germanium substrate.

33. The method as recited in Claim 31 wherein the nucleation layer comprises InGaP.

34. The method as recited in Claim 31 wherein the nucleation layer has a thickness substantially equal to 350 Å or less upon completion of said step (b).

35. The method as recited in Claim 31 wherein the dopant comprises phosphorus (P).

36. The method as recited in Claim 31 wherein the dopant comprises arsenic (As).

37. The method as recited in Claim 31 wherein the junction depth in the first cell layer is substantially between 0.3 μm and 0.7 μm upon completion of said steps (a) through (d).